What is claimed is:

1. A mixed-mode fuel injector, which is a high-accuracy couple of components comprising: (i) a nozzle body, which has fuel passages, which has inner cylindrical spaces for receiving a movable part, (ii) a needle valve, which has a converging-diverging conical head thereby guides the flow of fuel, which is movable back and forth and received in said nozzle body, wherein said needle valve is at a biased closing position or an opening position defined by driving means, (iii) a micro-variable-circular-orifice comprising a variable circular ring aperture between said needle valve and said nozzle body and a plurality of micro-channels, wherein it has means of discharging fuel in variable sprays of conical and conical-multi-jet shapes through said micro-variable-circular-orifice by lifting said needle valve at different magnitudes.

2. A fuel injector, which is a high-accuracy couple of components comprising: (i) a nozzle body, which has fuel passages, which has inner cylindrical spaces for receiving a movable part, which has a conical surface close to its tip for guiding fuel sprays, (ii) a needle valve, which has a converging-diverging conical head thereby guides the flow of fuel, which is movable back and forth and received in said nozzle body, wherein said needle valve is at a biased closing position or an opening position defined by driving means, (iii) a micro-variable-circular-orifice comprising a circular ring aperture between said needle valve and said nozzle body, wherein it has means of discharging fuel in variable sprays of conical shapes through said micro-variable-circular-orifice by lifting said needle valve at different magnitudes.

3. The fuel injector of claim 1, wherein close to the tip surface of nozzle body there is a conical surface for guiding fuel sprays, the conical surface can be a single conical surface, an integrated conical surface with two or more conical surfaces with different conical angles connected together, or a diverging curve surface.

4. The fuel injector of claim 1, wherein the needle lift for opening position is approximately in the range of 0-300μm, the needle head diameter is approximately in the

range of 0.8-3.5mm, the angle between the centerline of the nozzle body and the inner conical surface at the nozzle body tip is approximately in the range of 35-75 degree.

5. The fuel injector of claim 1 has a plurality of micro-channels on the said conical surface with the cross section shape of semi-circle, arcs, triangle, trapezoid or other polygons, the needle head is partially or fully merged in the tip surface of the nozzle body during the needle lifting, when the needle valve is lifted, fuel is injected through the micro variable aperture between the needle head and said conical surface of the nozzle body, fuel is also injected through the multiple micro-channels, the upper surface of the needle head and the conical surface(s) serve as guiding surfaces for fuel sprays.

6. The fuel injector of claim 5, wherein there are about 4-20 micro-channels with the cross-section shape of either semi-circles with the diameters approximately in the range of 50-300μm, or other shapes as described in claim 5 with the maximum dimension approximately between 50-400μm, the sizes of said micro-channels can be the same or different depending on specific needs of atomization, said micro-channels are distributed on or under the conical surface, thus it can be open channels or closed channels.

7. A fuel injector of claim 1 has a plurality of micro-channels underneath the said conical surface with the cross section shape of conventional nozzle holes, which can form sac-hole or valve-covered-orifice multi-hole type injector through blocking the circular aperture by the needle head at a predefined needle-lift range.

8. The fuel injector of claim 1 has means of generating different shapes of fuel sprays by changing the magnitude of lift of said needle valve, wherein at low to medium injection loads, fuel is mainly injected through the variable circular aperture between the needle head and nozzle body, thus mainly forms a conical shape spray, while at high injection loads, fuel is injected through both the variable circular aperture between the needle head and nozzle body and the micro-channels, thus forms a mixed-mode conical-multi-jet shape spray, whereby provides different atomization desired by engine combustion at different loads.

9. A fuel injector of claim 1 has means of generating different shapes of fuel sprays by changing the magnitude of lift of said needle valve, wherein at low to medium injection loads, fuel is mainly injected through the variable circular aperture between the needle head and nozzle body, thus mainly forms a conical shape spray, while at high injection loads, the needle head can completely or partially block the variable circular aperture, whereby fuel is fully or mainly injected through the micro-channels, which can be open channels or closed channels depending on penetration needs, thus mainly forms conventional multi-hole sprays at high loads, whereby provides different penetration desired by engine combustion at different loads.

10. The fuel injector of claim 2, wherein close to the tip surface of nozzle body there is a conical surface, the conical surface is of a single conical surface, an integrated conical surface comprising two or more conical surfaces with different conical angles, a diverging curve surface, the upper rim of the head of the needle valve is merged in the tip surface of the nozzle body during the needle lifting, when the needle valve is lifted, fuel is injected through said micro variable aperture between the needle head and conical surface of the nozzle body.

11. The fuel injector of claim 1 or claim 2, wherein the fuel channel between the needle valve and the nozzle body is of converging-diverging shape, by lifting said needle valve at different magnitudes, the minimum cross-section is at the sealing surface during the early stage of fuel injection, the minimum cross-section is at said micro-variable-circular-orifice or at the sealing surface during the middle stage of fuel injection, and the minimum cross-section is at the sealing surface again during the late stage of fuel injection, whereby it has means of ensuring fine atomization during all fuel injection stages.

12. The fuel injector of claim 1 or claim 2, wherein the angle between the centerline of the conical surface and the centerline of the nozzle body is approximately 0-15 degree,

depending on the angle between the centerline of the fuel injector and the centerline of the piston in the engine cylinder.

13. The fuel injector of claim 1 or claim 2, wherein the fluid injected can be diesel fuels, gasoline fuels, alternative fuels, mixtures of water and fuels, pure water, liquid exhaust cleaning additives, whereby serves as a general purpose injector.

14. A fuel injector of claim 1 or claim 2, wherein the needle valve is passively driven by high fuel pressure, whereby provides said driving means.

15. A fuel injector of claim 1 or claim 2, wherein the needle valve is actively driven by an actuator, which can be a solenoid or a piezo actuator, whereby provides said driving means.

16. A fuel injector, which has a micro-variable-circular-orifice (MVCO) comprising a variable circular ring aperture and multiple-micro-channels as in claim 1, wherein the MVCO is used as a sole orifice or in-combination with other multi-hole conventional orifice.

17. Those are skilled in the art will find that it's easy to make minor changes to the nozzle structure following the same principle illustrated in this invention, such as adding micro-channels or adding spirals on the needle head or the conical surface of the nozzle body, wherein outer surfaces of the nozzle body can be of cylindrical, conical, or converging-diverging shapes, whereby these ramifications are within the scope of this invention.